Experimental Investigation of the Taphonomy of Holocene Chicken Feathers

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TABLE OF CONTENTS

Abstract

This set of experiments was designed to gain insight into the potential for feathers to fossilize in a variety of depositional settings. Taphonomic experimentation on chicken feathers (*Gallus gallus domesticus*) took place in six different experimental settings: open air (protected, unprotected), freshwater (oxygenated, anoxic), and salt water (oxygenated, anoxic). Feathers showed surprising resistance to breakdown in most experimental settings. After eight weeks, feathers showed little or no obvious change except in the freshwater, oxygenated setting. Feathers in the freshwater, oxygenated setting began to break down in three weeks; structural integrity of the shaft was reduced, and barbs easily fell from the shaft.

Acknowledgments

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I want to thank The Ohio State University's Michael Cressman from the College of Food, Agriculture and Environmental Sciences for supplying the feathers.

Additionally, I would like to thank Loganne Gross, for the support throughout this whole process. Handling the transition of topics and performing the experiment would have been nearly impossible without her assistance

List of Figures

Figure 7b: Decay Halo and broken-down feather

Decay halo surrounding the same feather as in Figure 7a. The fragile nature of the feather, and the separation of barbs, are both evident from pieces in the aquarium. This photo shows deterioration of the feather after eight weeks of being in the water.

List of Table

Introduction

Feathers are rarely reported from the fossil record. This makes looking into potential issues of preservation important for understanding why our knowledge and records are so small. Seeing how feathers decay and disintegrate under varied environmental circumstances can provide insight into why feathers are so rare, and may provide insight as to which environments are most conducive to preserving them.

In this experimental taphonomic investigation, fresh Holocene chicken feathers (*Gallus gallus domesticus*) were subjected to six different environmental settings, each mimicking a natural taphonomic/depositional setting. The work expands on a similar set of experiments reported by Babcock (1998). The present work adds new information on the relative preservability of feathers, which are now known from a variety of Mesozoic and Cenozoic theropod dinosaurs, especially birds (e.g., Eliason et al., 2017; Xu et al., 2017; Kaye et al., 2019).

Methods and Materials

For this set of experiments, chicken feathers were subjected to various aquatic and open-air environments to assess their relative preservability in varied depositional environments. The chicken feathers were obtained from The Ohio State University's College of Food, Agriculture and Environmental Sciences. Three feathers were used for each experimental setting except the two anoxic ones. In these settings only two feathers were used. This made for a total of 16 feathers.

The environments simulate four aquatic depositional environments and two non-aquatic depositional environments on a small scale. Aquaria were used to host aquatic media. Fresh water was obtained from Columbus City Water sources, and allowed to sit for one week before use, which permitted chlorine and other components to dissipate. Marine water was mixed from fresh water and marine salts ("Instant Ocean") obtained at a commercial aquarium store. Fresh and marine water were inoculated with microorganisms, already present in the aquaria, and on chicken carcasses, prior to the start of the experiments. Oxygen was added to fresh water and marine aquaria by way of standard aquarium aerators. Anoxic fresh water was obtained by placing fresh water and rotting chicken carcass together in a ziplock bag, closing it, and floating it in the fresh water aquarium. The bag remained closed throughout the experiment. An anoxic marine environment was produced in the same manner using inoculated marine water as a base. In the oxygenated aqueous environments there were floating and submerged feathers. Some feather specimens were allowed to sit in dry air, protected, indoors throughout the experiment; and others were allowed to sit in dry air, unprotected, outdoors.

Experimental Settings

Six experimental settings were used. This was to ensure a wide variety of tests to try and find how resilient to breakdown feathers can be across environmental types. The experimental settings did not involve waves or flow of water. There were two open air environments, one indoors to function as a control, and one outdoors to simulate on-land deposition. Two of the aquatic aquaria were freshwater, one had oxygenated water, and one had anoxic water. These two were to simulate lake environments. The last two experiments involved salt water, with both oxygenated and anoxic environments represented.

Experiments were run in Columbus, Ohio, for a period of eight weeks during the months of April-June, 2021.

Results

Open Air, Protected Setting

After eight weeks, feathers in the open air, protected experimental setting (inside an apartment) showed no obvious change (Figure 1, Table 1). They appeared to be indiscernible from how they looked at the start of the testing. Full strength of the feathers was maintained, and there were no signs of detachment of the barbs. Color stayed the same as well. Without assistance or expediting factors, the feathers are rather resilient.

Figure 1: A feather that was maintained indoors, in an open air, protected experimental setting. Effectively this feather is the same as it was at the beginning.

Open Air, Unprotected Setting

After eight weeks, feathers left outside during the months of April-June, in an unprotected experimental setting, became a darker color (Figure 2, Table 1). Exposed to elements the feathers showed not only discoloration, but also minor damage to the barbs. This was easily attributed to rain, leaves, and dirt, which got the barbs dirty. The structural integrity of the feathers seemed no different from

the feathers left indoors. There were no attempts by other organisms to scavenge or use the feathers in any way. Various birds, rodents, and insects all would pass the feathers without hesitation.

Figure 2: A feather that was maintained outside in an open air, unprotected experimental setting. Exposed to elements there is some damage to the barbs and discoloration.

Salt Water, Anoxic Setting

For about six weeks, feathers in the salt water, anoxic experimental setting showed little sign of any change. However, in the last one to two weeks there was a color change to the feathers. The shafts of the feathers took on a slight turquoise blue color (Figure 3, Table 1). This suggests that there was some form of decomposition or alteration occurring. At six to seven weeks, the shafts had become flexible, and apparently the inner parts of the shafts were broken down and gone. However, the physical dimensions of the shafts and the attachment of barbs remained relatively unchanged.

Figure 3: A feather from the salt water, anoxic experimental setting. Rigidity of the feather is diminished, and the color of the shaft is turquoise blue.

Freshwater, Anoxic Setting

Feathers in the freshwater, anoxic experimental specimen showed minor loss of integrity of the shaft after eight weeks (Figure 4, Table 1). This was the only evidence of weakening though. The shaft was still holding together, and the

barbs remained attached to it. The specimen in Figure 4 shows there was a color change to the barbs and where they connected to the shaft. This color change did not seem to be associated with a degradation of strength.

Figure 4: A feather maintained in a freshwater, anoxic experimental setting showed little change.

Salt Water, Oxygenated Setting

Feathers in the salt water, oxygenated experimental setting were relatively unaffected after eight weeks. The shafts were slightly more flexible than they were originally. The barbs and shaft remained intact with minimal color change as

(Figure 5, Table 1). In this environment setting, feathers at the conclusion of the experiment look much as they did at the beginning of the experiment. Of all the aqueous experimental settings, feathers in this setting appeared most similar in all ways to the original condition. Only feathers left in the open air seemed as minimally changed after eight weeks (although specimens left outdoors had become discolored).

Figure 5: A feather from the salt water, oxygenated experimental setting. Almost no color change has taken place, except for a yellowish tint towards the bottom of the shaft, and structural integrity is nearly unchanged after eight weeks.

Freshwater, Oxygenated Setting

Feathers in the freshwater, oxygenated experimental setting showed the greatest amount of change after eight weeks (Figure 6, Table 1). For the early part of the experiment they showed little change, but by three weeks they did show the development of a "decay halo," presumably composed of fungi and bacteria (see Borkow and Babcock, 2003) around them (Figure 7a, 7b, Table 1). The decay halo continued to increase in size over time on some feathers. Some feathers changed color, to black, on the shaft (Figure 6). Originally, before the color change, it seemed the feathers were maintaining their structural stability. However, when I went to move them, the tips of shafts snapped off. The barbs also dropped off when minor pressure was applied (Figures 6, 7b). The structural integrity of these feathers had been compromised.

Figure 6: A feather from the freshwater, oxygenated experimental setting shows color change on the shaft, and loss of some barbs upon application of slight pressure, after eight weeks of time.

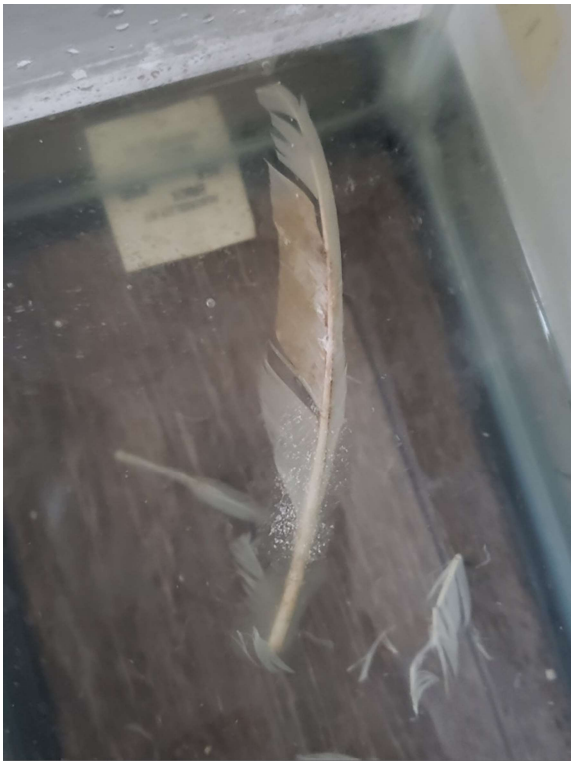

Figure 7a: A fungal-bacterial decay halo (Borkow and Babcock, 2003) surrounding a feather from the freshwater, oxygenated experimental setting. This is the appearance of the halo on the feather after eight weeks of being in the water. Deterioration of the barbs and shaft have also taken place.

Figure 7b: Decay halo surrounding the same feather as in Figure 7a. The fragile nature of the feather, and the separation of barbs, are both evident from pieces in the aquarium. This photo shows deterioration of the feather after eight weeks of being in the water.

Table 1. Taphonomic changes to feathers in each of the six experimental settings.

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Open Air Protected setting	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Open Air Unprotected setting	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Freshwater, Oxygenated setting	N/A	N/A	Decay halo present	Decay halo present	Decay halo present	Integrity removed, structure decayed	Integrity removed, structure decayed	Integrity removed, structure decayed
Freshwater, anoxic setting	N/A	N/A	N/A	N/A	N/A	Integrity weakened	Integrity weakened	Integrity weakened
Saltwater, Oxygenated setting	N/A	N/A	N/A	N/A	N/A	N/A	Integrity weakened	Integrity weakened
Saltwater, Anoxic setting	N/A	N/A	N/A	N/A	Integrity weakened	Integrity weakened	Integrity weakened	Integrity weakened

Discussion

Implications for preservation as fossils

These results show that feathers break down rather slowly, over a period of weeks, in oxygenated freshwater. The feathers in this setting are vulnerable to decay and disarticulation (Figures 7a, 7b). In a natural freshwater, oxygenated setting, feathers could be expected to fossilize only if they were buried relatively quickly. Fossilization under these conditions, then, would be expected to be uncommon.

In each of the other experimental settings, feathers showed little or no obvious change after eight weeks. In the absence of other taphonomic filters, feathers from any of these settings could be expected to maintain their structural integrity long enough to become buried and to fossilize.

Under less controlled, natural conditions, forces such as wind and waves may play a role in diminishing a feather's preservation potential, although that possibility was not tested in this experimental model. Waves from the ocean, for example, could present an abrasive force that leads to greater destabilization of the feathers' rather strong structure. Larger and more dynamic depositional environments may partly account for why feathers are so uncommon to find preserved as fossils.

Another reason that feathers are uncommon as fossils could be that, when buried, organisms that live in the sediment are more attracted to the keratin base of the feathers than are surface-dwelling creatures. If these organisms and other decomposers are around, the structural integrity of the feathers may be compromised.

Importance of Feathers

Although feathers have been found associated with a number fossil theropods, their prevalence in the fossil record is low. Whether this is due to poor preservation potential or a low rate of collecting and observation is unknown. However, the results of these experiments suggest that feathers generally should have good potential for preservation as fossils. It is possible that other factors, not accounted for in these experiments, reduced the preservability of feathers under natural conditions. Feathers are readily recognized when well preserved, but perhaps we struggle to recognize them when they are poorly preserved.

Understanding where feathers begin in a specific evolutionary line of organisms, and where the very first feathers evolved, is something the scientific community has yet to fully ascertain. Getting a full picture of how they first formed, and their function could be a bountiful source of information. Finding transitionary fossils sheds light onto evolutionary paths and origins that help build a better picture of the past and its connection to the present. The evolution of feather-bearing troodontids comprises one aspect of this endeavor (Xu et al., 2017). Ever since feathers were found on dinosaurs there has been a stir in the public. Rousing the public interest is important for all levels of science and feathers do a wonderful job. Some of the most beautiful things people can see are in their backyards are birds. Some of the most captivating fossils are feathers. Making the general public excited about visiting museums, will help sustain museums and similar projects.

Interestingly, many of the natural locations that have fossilized feathers are freshwater lakes (see Eliason et al., 2017). This indicates that there are factors besides water type and quality that influence preservation. Speed of burial likely plays a large role in whether preservation takes place.

Conclusions

Feathers are surprisingly resilient and durable. Under the best of circumstances, they take weeks to break down, which suggests that they should have a relatively high preservation potential. Outdoors, animals seem to have little interest in scavenging feathers. Feathers degrade most readily in freshwater, oxygenated settings, but even under these conditions, breakdown requires weeks to take place.

This work shows the feathers are more resilient to breakdown than expected. Why feathers are so uncommonly reported as fossils is unknown. One possibility is that they have often gone unrecognized. Feathers may have been preserved more commonly, but processed away during excavation and specimen preparation. The less well-preserved feathers may not have been obvious, and removed as extraneous rock.

Future Research

Two potential variations on these experiments could provide more insight into this subject. One variation would involve using the same conditions but simulating waves or other current action. A moving current source may have an important impact on preservation potential of feathers. Another variation would be to use the same environments but bury the feathers in various sediments. This could help determine whether certain sediments protect them from decay more than others.

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